CLAIMS

What is claimed is:

1. A method of controlling a cryopump, the method comprising:

determining an unsafe condition in a cryopump; and

in response to the unsafe condition, directing purge gas into the cryopump by opening a purge valve, and preventing any host controller from controlling the purge valve until the unsafe condition changes to a safe condition.

2. A method according to Claim 1 wherein opening the purge valve comprises releasing a normally open purge valve.

3. A method according to Claim 1 wherein directing purge gas into the cryopump further includes cycling between opening and closing the purge valve.

4. A method according to Claim 1 wherein the response to the unsafe condition further includes directing purge gas into an exhaust system coupled to the cryopump by opening an exhaust purge coupled to the exhaust system.

5. A method according to Claim 4 further includes preventing any host controller from controlling the exhaust purge valve until the unsafe condition changes to a safe condition.

6. A method according to Claim 4 wherein opening the exhaust purge comprises releasing a normally open exhaust purge valve.

7. A method according to Claim 4 wherein directing purge gas into the exhaust system includes cycling between opening and closing the exhaust purge valve.

8. A method according to Claim 1 wherein an unsafe condition exists when there is any one of: a power failure of the cryopump; or a temperature of the cryopump greater than or equal to a predetermined temperature threshold; or an inability to determine a temperature of the cryopump.

9. A method according to Claim 8 further comprising responding to the power failure by:

determining an operating state of the cryopump before the power failure; and

if the operating state indicates that the cryopump was in a process of regeneration when the power failed, determining whether initiating a regeneration process is appropriate.

10. A method according to Claim 1 wherein the unsafe condition changes to a safe condition after purge gas has been directed into the cryopump for a predetermined amount of time.

11. A method according to Claim 1 further includes the step of:

responding to an unsafe condition which changes to a safe condition by determining whether regeneration of the cryopump is necessary.

12. A method according to Claim 1 further includes the step of:

preventing regeneration of the cryopump while a gate valve of the cryopump is open.

13. A method according to Claim 1 wherein the response to the unsafe condition further includes:

delaying directing purge gas into the cryopump and delaying preventing any host controllers from controlling the purge valve until the predetermined amount of time elapses; and

if the unsafe condition still exists when the predetermined amount of time elapses, initiating opening the purge valve and preventing any host controller from controlling the purge valve.

14. An electronic controller for controlling a cryopump, the controller is programmed with instructions for:

determining an unsafe condition in the cryopump;

admitting purge gas into the cryopump by directing a purge valve to open; and

preempting any attempts from any other controllers to control the purge valve until the unsafe condition changes to a safe condition.

15. An electronic controller according to Claim 14 wherein the purge valve is directed to open by releasing a normally open purge valve.

16. An electronic controller according to Claim 14 wherein admitting purge gas into the cryopump further includes cyclically opening and closing the purge valve.

17. An electronic controller according to Claim 14 wherein the instructions for responding to an unsafe condition further include instructions for:

admitting purge gas into an exhaust line which is coupled to the cryopump by directing an exhaust purge valve which is coupled to the exhaust line to open until the unsafe condition changes to a safe condition.

18. An electronic controller according to Claim 17 further includes preempting any attempts from any other controllers to control the exhaust purge valve until the unsafe condition changes to a safe condition.

19. An electronic controller according to Claim 17 wherein directing the exhaust open includes releasing a normally open purge valve.

20. An electronic controller according to Claim 17 further includes cyclically opening and closing the exhaust purge valve.

21. An electronic controller according to Claim 14 wherein an unsafe condition includes any of: a power failure of the cryopump; or a temperature of the cryopump greater than or equal to a predetermined temperature threshold; or an inability to determine a temperature of the cryopump.

22. An electronic controller according to Claim 21 wherein the instructions for responding to an unsafe condition that is a power failure further include instructions for:

determining an operating state of the cryopump before the power failure; and

if the operating state indicates that the cryopump was in a cool down phase of regeneration when the power failed, initiating a regeneration cycle.

23. An electronic controller according to Claim 14 wherein the unsafe condition changes to a safe condition after purge gas has been admitted into the cryopump for a predetermined amount of time.

24. An electronic controller according to Claim 14 further include instructions for:

responding an unsafe condition that changes to a safe condition by determining whether regeneration of the cryopump is necessary.

25. An electronic controller according to Claim 14 further include instructions for:

preventing regeneration of the cryopump while a gate valve of the cryopump is open.

26. An electronic controller according to Claim 14 wherein the instructions for responding to an unsafe condition further include instructions for:

for a predetermined amount of time, delaying the instructions for directing purge gas into the cryopump and delaying preempting any attempts from any other controllers to control the purge valve; and

if the unsafe condition still exists when the predetermined amount of time elapses, initiating the instructions for directing purge gas into the cryopump and preempting any attempts from any other controllers to control the purge valve.

27. A cryopump comprising:

a cryopump chamber having pumping surfaces;

a purge valve coupled to the cryopump; and

an electronic controller which controls the cryopump, the controller is capable of determining whether the cryopump is operating in a safe or unsafe condition, the purge valve is automatically controlled by the controller in response to an unsafe condition, the controller overriding any other systems.

28. A cryopump according to Claim 27 wherein in response to an unsafe condition, the controller causes the purge valve to open by releasing a normally open valve.

29. A cryopump according to Claim 28 wherein the controller further responds to the unsafe condition by causing the purge valve to cycle between open and closed states.

30. A cryopump according to Claim 28 wherein the controller further responds to the unsafe condition by:

waiting to cause the purge valve to open until after a predetermined period of time has elapsed; and

if the predetermined time has elapsed and the unsafe condition remains, causing the purge valve to open.

31. A cryopump according to Claim 27 wherein the controller overrides any other systems during an unsafe condition.

32. A cryopump according to Claim 27 further includes:

an exhaust line coupled to the cryopump; and

an exhaust purge valve coupled to the exhaust line, wherein the controller further responds to an unsafe condition by:

automatically controlling the exhaust purge valve; and

causing the exhaust purge valve to open by releasing a normally open valve.

33. A cryopump according to Claim 31 wherein the controller further responds to the unsafe condition by causing the exhaust purge valve to cycle between open and closed states.

34. A cryopump according to Claim 27 wherein an unsafe condition includes any of: a power failure; or a temperature of the pumping surfaces being greater than or

equal to a predetermined temperature threshold; or an inability to determine a temperature of the pumping surfaces.

35. A cryopump according to Claim 27 wherein the controller further responds to an unsafe condition by:

determining an operating state of the cryopump before the power failure; and

if the operating state indicates that the cryopump was in a process of regeneration when the power failed, determining whether initiating a regeneration process is appropriate.

36. A cryopump according to Claim 27 wherein the unsafe condition changes to a safe condition after a predetermined amount of time has elapsed.

37. A cryopump according to Claim 27 wherein the controller responds to an unsafe condition that changes to a safe condition by determining whether regeneration of the cryopump is necessary.

38. A cryopump according to Claim 27 wherein the controller is programmed to prevent regeneration of the cryopump while a gate valve of the cryopump is open.

39. A system for controlling a cryopump, the system comprising:

a means for determining an unsafe condition in a cryopump;

a means for responding to the unsafe condition by directing purge gas into the cryopump by opening a purge valve, and preventing any host controller from controlling the purge valve until the unsafe condition changes to a safe condition.

40. A method of controlling a cryopump, the method comprising:

determining if a temperature sensors is functioning properly; and

responding to a temperature sensor which is not functioning properly by directing a purge valve to open.

41. A method according to Claim 40 wherein the purge valve is either a cryo-purge valve coupled to a cryopump or an exhaust purge valve coupled to an exhaust line of a cryopump.

42. A method according to Claim 40 wherein the purge valve is maintained open for a period of time.

43. A method according to Claim 42 wherein maintaining the purge valve for a period of time further includes preventing any other system from closing the purge valve.

44. A method according to Claim 42 wherein directing the purge valve to open further includes delivering purge gas into a cryopump without initiating an entire regeneration process.

45. A method according to Claim 40 directing a purge valve to open further includes cycling between opening and closing the purge valve.

46. A method according to Claim 40 directing a purge valve to open further includes releasing a normally open purge valve.

47. An electronic controller which monitors one or more temperature sensors coupled to a cryopump, the controller programmed with instructions for:

determining an operating status of one or more temperature sensors coupled to a cryopump; and

if one of the temperature sensors does not appear to be operating, initiating a safe purge.

48. An electronic controller according to Claim 47 wherein a safe purge includes maintaining a purge valve open for a limited period of time.

49. An electronic controller according to Claim 48 wherein the purge valve comprises at least one of a cryo-purge valve coupled to the cryopump, or an exhaust purge valve coupled to an exhaust line of the cryopump.

50. An electronic controller according to Claim 47 wherein the controller ensures that the safe purge cannot be aborted.

51. An electronic controller according to Claim 47 wherein the safe purge further comprises delivering purge gas into the cryopump without initiating an entire regeneration process.

52. An electronic controller according to Claim 47 wherein the safe purge further includes cycling between opening and closing a purge valve.

53. An electronic controller according to Claim 47 wherein the safe purge further includes releasing a normally open purge valve.

54. A cryopump comprising:

a purge valve coupled to the cryopump;

one or more temperature sensors coupled to the cryopump; and

an electronic controller coupled to the cryopump, the controller configured to determine whether any of the temperature sensors are malfunctioning, the controller initiates a safe purge when one of the temperature sensors has malfunctioned.

55. A cryopump according to Claim 54 wherein the safe purge includes holding a purge valve opened for a period of time.

56. A cryopump according to Claim 54 wherein the purge valve comprises at least one of a cryo-purge valve coupled to the cryopump, or an exhaust purge valve coupled to an exhaust line of the cryopump.

57. A cryopump according to Claim 54 wherein the controller ensures that the safe purge cannot be aborted.

58. A cryopump according to Claim 54 wherein the safe purge further comprises delivering purge gas into the cryopump without initiating an entire regeneration process.

59. A cryopump according to Claim 54 wherein the safe purge further includes cycling between opening and closing a purge valve.

60. A cryopump according to Claim 54 wherein the safe purge further includes releasing a normally open purge valve.

61. A system for controlling a cryopump, the system comprising:

a means for determining whether a temperature sensor coupled to a cryopump is failing; and

a means for responding to a temperature sensor which fails by opening a purge valve.

62. A power failure recovery method in a cryopump, the method comprising:

after every power failure, responding to restored power in a cryopump by:

determining whether the cryopump has warmed above a recovery temperature set point; and

if the cryopump has warmed above the recovery temperature set point, directing a purge valve to open and assuring that the purge valve remains open for a period of time.

63. A power failure recovery method according to Claim 62 the purge valve that is directed to open is at least one of a cryo-purge valve coupled to the cryopump or exhaust purge valve coupled to an exhaust line of the cryopump.

64. A power failure recovery method according to Claim 62 further includes:

if a temperature sensor coupled to the cryopump is not operating properly, directing the purge valve to open to emit purge gas into the cryopump.

65. A power failure recovery method according to Claim 62 further includes:

determining the operating state of the cryopump when power loss occurred; and

if the operating state of the cryopump indicates that at the time of power loss the cryopump was in a regeneration, initiating a regeneration of the cryopump.

66. A power failure recovery method according to Claim 62 further includes ensuring that the response to restored power cannot be aborted.

67. A power failure recovery method according to Claim 62 wherein directing the purge valve to open comprises delivering purge gas into the cryopump without initiating an entire regeneration process.

68. A power failure recovery method according to Claim 62 wherein the directing the purge valve to open further includes cycling between opening and closing the purge valve.

69. A power failure recovery method according to Claim 62 wherein the directing the purge valve to open further includes releasing a normally open purge valve.

70. A power failure recovery method according to Claim 62 wherein the recovery temperature set point is 34K.

71. An electronic controller for controlling a cryopump, the controller is programed with instructions for responding to a restoration of power in a cryopump after every power failure by:

determining whether the cryopump has warmed above a recovery temperature set point; and

if the cryopump has warmed above the recovery temperature set point, directing a purge valve in the cryopump to open and assuring that the purge valve remains open for a period of time.

72. An electronic controller according to Claim 71 the purge valve that is directed to open is any cryo-purge valve coupled to the cryopump or exhaust purge valve coupled to an exhaust line of the cryopump.

73. An electronic controller according to Claim 71 wherein the instructions for responding to a restoration of power further include instructions for:

directing the purge valve to open to emit purge gas into the cryopump if a temperature sensor coupled to the cryopump is not operating properly.

74. An electronic controller according to Claim 71 wherein the instructions for responding to a restoration of power further include instructions for:

determining the operating state of the cryopump when power loss occurred; and

if the operating state of the cryopump indicates that at the time of power loss the cryopump was in a regeneration, initiating a regeneration of the cryopump.

75. An electronic controller according to Claim 71 wherein the instructions for responding to a restoration of power cannot be aborted.

76. An electronic controller according to Claim 71 wherein directing the purge valve to open comprises delivering purge gas into the cryopump without initiating an entire regeneration process.

77. An electronic controller according to Claim 71 wherein directing the purge valve to open further includes cycling between opening and closing the purge valve.

78. An electronic controller according to Claim 71 wherein the directing the purge valve to open further includes releasing a normally open purge valve.

79. An electronic controller according to Claim 71 wherein the recovery temperature set point is 34K

80. A cryopump comprising:

a temperature sensor inside the cryopump;

a purge valve coupled to the cryopump; and

an electronic control system coupled to the cryopump, after every power failure the control system responds to a restoration of power by:

using the temperature sensor, determining whether the cryopump has warmed above a recovery temperature set point; and

if the cryopump has warmed above the recovery temperature set point, directing the purge valve to open and assuring that the purge valve remains open for a period of time.

81. A cryopump according to Claim 80 wherein if the controller responds to the power restoration of power by directing the purge valve to open, the controller further responds by directing an exhaust valve coupled to an exhaust line of the cryopump to open.

82. A cryopump according to Claim 80 wherein the control system further responds to a restoration of power by:

directing the purge valve to open to emit purge gas into the cryopump if the temperature sensor inside the cryopump is not operating properly.

83. A cryopump according to Claim 80 wherein the control system further responds to a restoration of power by:

determining the operating state of the cryopump when power loss occurred; and

if the operating state of the cryopump indicates that at the time of power loss the cryopump was in a regeneration process, initiating a regeneration of the cryopump.

84. A cryopump according to Claim 80 wherein the response to a restoration of power cannot be aborted.

85. A cryopump according to Claim 80 wherein directing the purge valve to open comprises delivering purge gas into the cryopump without initiating an entire regeneration process.

86. A cryopump according to Claim 80 wherein directing the purge valve to open further includes cycling between opening and closing the purge valve.

87. A cryopump according to Claim 80 wherein the directing the purge valve to open further includes releasing a normally open purge valve.

88. A cryopump according to Claim 80 wherein the recovery temperature set point is 34K.

89. A system for recovering from a power failure recovery, the system comprising:

a means for determining whether a temperature is above a recovery temperature set point after every power failure;

a means for directing a purge valve to open when the temperature is above the recovery temperature set point; and

a means for assuring that the purge valve remains open for a period of time.